comprising a micro-display, illumination optics, and image optics, in which the micro-display projects the image light into the waveguide display at the in-coupling DOE, wherein the illumination optics include an illumination light source, comprising one of laser or LED (light emitting diode), and a MEMS (micro-electro mechanical system) scanner configured for raster scanning light from the illumination light source to illuminate the micro-display.

In another example, the MEMS scanner is a dual-axis scanner operated in reflection using a moveable reflective surface and further is arranged for fast scanning along a first axis and slow scanning along a second axis. In another example, the waveguide display further includes at least one intermediate DOE and an out-coupling DOE, wherein the at least one intermediate DOE provides exit pupil expansion in a first direction of the FOV and the out-coupling DOE provides exit pupil expansion in a second direction of the FOV. In another example, the micro-display comprises one of an LCOS (liquid crystal on silicon) panel operating in reflection, a pixel array, or an image source using one or more of light emitting diode (LED), OLED (organic light emitting diode), liquid crystal (LC), or digital light processing (DLP). In another example, the near-eye optical display system further includes post-scan optics in an optical path between the MEMS scanner and the LCOS panel. In another example, the post-scan optics include one or more of microlens array, magnifying lens, or collimating lens.

A further example includes a head mounted display (HMD) device configured to display images within a field of view (FOV) having first and second directions with improved non-uniformity, comprising: an imaging panel that produces virtual images; illumination optics configured to provide illumination light to the imaging panel from a source using a MEMS (micro-electro mechanical system) device operating to raster scan illumination light onto the imaging panel; a combiner comprising one of numerical aperture (NA) converter or exit pupil expander (EPE); and imaging optics configured to couple image light from the imaging panel into the combiner.

In another example, the imaging panel operates in one of transmission or reflection. In another example, the imaging optics include one of birdbath imaging optics or direct eyepiece optics. In another example, the MEMS device is operated to provide raster scanning through a fast axis and a slow axis. In another example, the EPE comprises waveguide-based display comprising one or more diffractive optical elements (DOEs) configured for in-coupling light from the imaging panel, expanding an exit pupil of the image light, and out-coupling the image light from the display with expanded exit pupil. In another example, the imaging optics further comprise magnifying or collimating optics to provide increased exit pupil and field of view of the displayed images.

A further example includes a device configured to control image light associated with virtual images within a field of view (FOV), comprising: an imager configured to generate the virtual images; a waveguide display including an in-coupling diffractive optical element (DOE) configured to in-couple virtual image light into the waveguide display, at least one intermediate DOE configured to expand an exit pupil of the image light in a first direction of the FOV, and an out-coupling DOE configured to expand the exit pupil of the image light in a second direction of the FOV and further configured to out-couple image light out of the waveguide display to an eye of a user of the device; and a MEMS (micro-electro mechanical system) scanner configured to perform raster scanning of illumination light from an illumination light source to illuminate the imager to thereby generate the virtual image light.

In another example, the device further comprises birdbath imaging optics comprising one or more of fold mirror or polarization beam splitter and one or more lenses configured for magnifying or collimating the virtual image light. In another example, the imager is a micro-display. In another example, the illumination light source is a laser. In another example, the virtual images are color images using different colors, and the MEMS scanner is operated to modulate per-color intensity. In another example, the imager is operated using an RGB (red, green, blue) color model. In another example, the waveguide display is configured as a near-eye display. In another example, the MEMS scanner and imager are operated as a pico projector.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed:

1. An optical display system configured to show images within a field of view (FOV), comprising:

a waveguide operable as a near-eye display comprising one or more diffractive optical elements (DOEs) including an in-coupling DOE configured for in-coupling image light to the waveguide; and

a light engine comprising a micro-display, illumination optics, and image optics, in which the micro-display projects the image light into the waveguide at the in-coupling DOE,

wherein the illumination optics include

an illumination light source, comprising one of laser or LED (light emitting diode), and a MEMS (micro-electro mechanical system) scanner configured for raster scanning light from the illumination light source to illuminate the micro-display.

2. The optical display system of claim **1** in which the MEMS scanner is a dual-axis scanner operated in reflection using a moveable reflective surface and further is arranged for fast scanning along a first axis and slow scanning along a second axis.

3. The optical display system of claim **1** in which the waveguide further includes at least one intermediate DOE and an out-coupling DOE, wherein the at least one intermediate DOE provides exit pupil expansion in a first direction of the FOV and the out-coupling DOE provides exit pupil expansion in a second direction of the FOV.

4. The optical display system of claim **1** in which the micro-display comprises one of an LCOS (liquid crystal on silicon) panel operating in reflection, a pixel array, or an image source using one or more of light emitting diode (LED), OLED (organic light emitting diode), liquid crystal (LC), or digital light processing (DLP).

5. The optical display system of claim **4** further including post-scan optics in an optical path between the MEMS scanner and the LCOS panel.

6. The optical display system of claim **5** in which the post-scan optics include one or more of microlens array, magnifying lens, or collimating lens.

7. A head mounted display (HMD) device including a chain of optical elements configured to display images to a user's eye within a field of view (FOV) having first and second directions with improved non-uniformity, the optical elements comprising: